



# Solar Energy and the United States Measurement System

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Solar Energy and the United States Measurement System



Clare Allocca is the Chief of The United States Measurement System (USMS) Office at the National Institute of Standards and Technology (NIST). She has 23 years of experience in the conduct of advanced materials, surface engineering and measurement technology R&D, program management, strategic planning, customer engagement and process development/implementation.

She holds Bachelor of Science Degrees in Materials Science and Engineering and Geochemistry from the Massachusetts Institute of Technology; a Master of Science Degree in Ceramic Engineering from the University of Illinois at Urbana-Champaign; and an Executive Master of Science Degree in the Management of Technology from the University of Pennsylvania (Wharton Business School / School of Engineering). Before joining NIST, she was a Senior Materials Engineer for Pratt & Whitney engaged in the development of advanced ceramic composites for jet engines.



Slide 1



**Laurie Aldape** is a chemical engineer with Energetics, Incorporated. She has a Chemical Engineering B.S. from University of Maryland, College Park and an Environmental Engineering M.S. from University of California, Berkeley. Her 10 plus years of experience includes international business consulting, remediation engineering, and renewable energy consulting. Ms. Aldape currently provides technical and analytical support for both private and public sector clients, primarily within the renewable energy and chemical sectors.



Slide 1



## Objectives

- ✿ What is the United States Measurement System (USMS)?
- ✿ What does it mean to Assess the USMS?
- ✿ What is the Measurement Knowledge Hub?
- ✿ Measurement Needs and Solutions in Solar Energy
- ✿ Discussion of Opportunities
- ✿ The Path Forward



**Are you aware of the existence of the 2007 USMS Assessment Report?**

Polls are open.

Yes



No



[ Poll 2 ]



# United States Measurement System

## What?

- The set of measurement solution providers and users, and the relationships among them

## Why?

- Promote U.S. innovation and industrial competitiveness via
  - Increased effectiveness and efficiency in developing and deploying measurement solutions

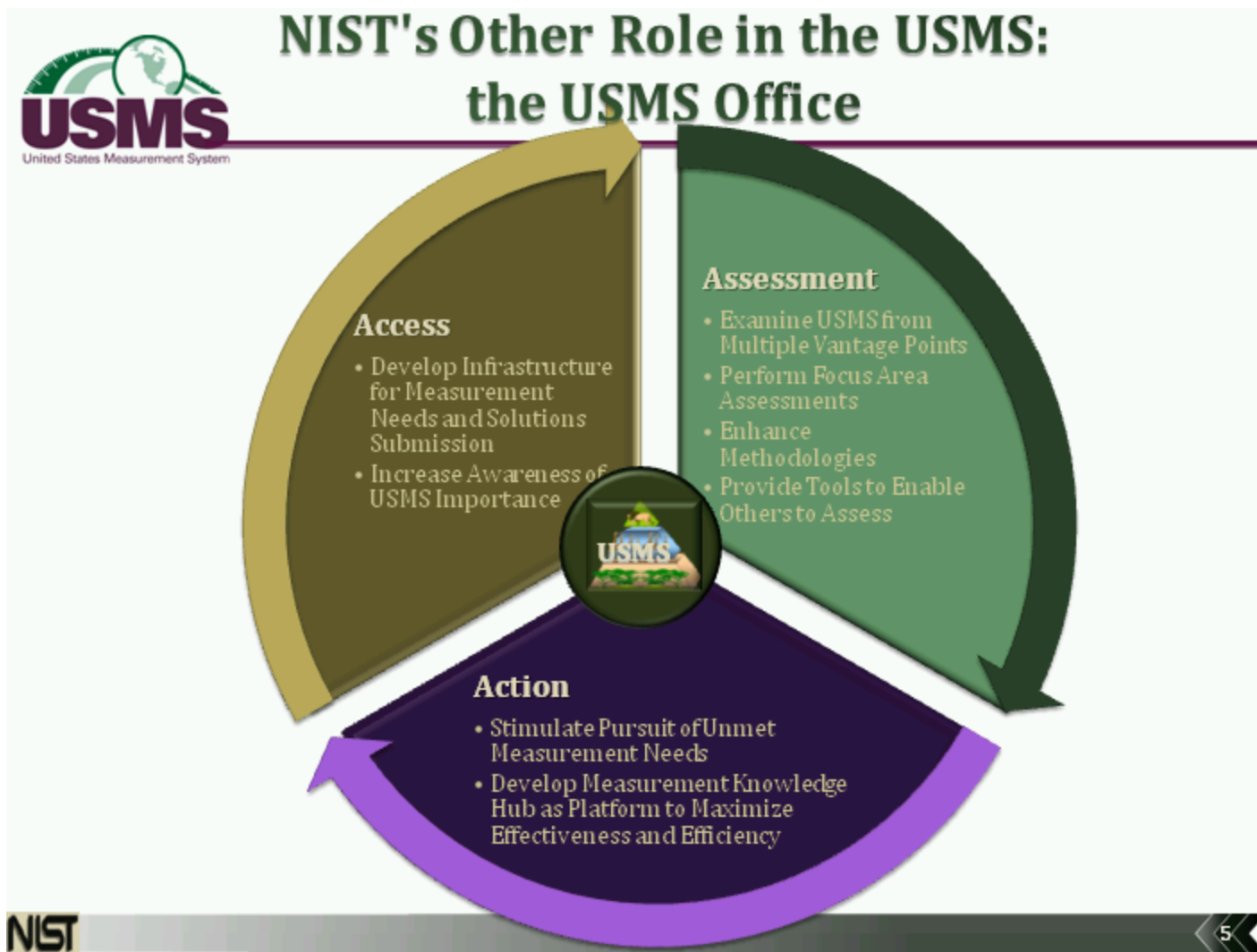
## How?

- By identifying and fostering efforts to address unmet measurement needs



- Documents 723 measurement barriers to innovation
- Covers 11 industry sectors
- Over 1000 contributors from industry, academia, and other government agencies





NIST's Other Role in the USMS: the USMS Office



## Action: What's in it for me?

- ✧ Inform strategic decision making
- ✧ Accelerate development of critical measurement solutions
  - ✧ Identify and authenticate existing measurement needs & solutions
- ✧ Customer Input (e.g. Needs, Priorities)
- ✧ Identify opportunities / Educate / Communicate



Action: What's in it for me?



## Basis for Assessment: Authenticated Measurement Needs (MN)

- MN Template
- Tags / Indicators
  - ✧ MN Characteristics that may be used to compare MNs
- Authentication
  - ✧ Evidence of a significant number of interested users for any measurement solution that is developed



Basis for Assessment: Authenticated Measurement Needs (MN)



## Case Study Measurement Need: Uncertainty of Photovoltaic Module Power Ratings

- ***Technological Innovation at Stake:*** Early-adopters in the building industry have begun using PV to meet a portion of their electrical energy needs... **PV module production is accelerating** due to increased demand for energy, decreasing costs, and financial incentives.
- ***Economic Significance of Innovation:*** The photovoltaic market is projected to quadruple to \$20 billion by 2010. **One of the greatest issues facing the industry is the uncertainty associated with PV module power ratings. The economic consequence of this uncertainty will approach \$200 million by 2010.**
- ***Technical Barrier to the Innovation:***...Industry's use of various lamp sources to replicate the solar spectrum, the lack of spectral measurements coincident with power measurements, and lack of standard testing methodologies are leading contributors to the uncertainty.



Case Study Measurement Need: Uncertainty of Photovoltaic Module Power Ratings



## Case Study Measurement Need: Uncertainty of Photovoltaic Module Power Ratings

- ***Measurement-Problem Part of Technical Barrier:*** Accurate measurement techniques to capture the spectrum of high-speed (<10 ms) flash solar simulators used in industrial environments do not exist. Improved measurement techniques resulting in reduced uncertainties in spectral and temperature response functions for PV cell technologies need to be developed. Methods to accurately measure the temperature of PV modules during high-speed flash testing need to be developed.
- ***Stage of Innovation Where Barrier Appears:*** Marketplace
- ***Potential Solutions to Measurement Problem:*** R&D to develop lamps that closely replicate the solar spectrum. Improved high-speed spectral measurements that can be realized in an industrial environment. An in-depth uncertainty analysis to identify individual measurement contributions to overall uncertainty budget. The combined results of these efforts will reduce the overall uncertainty in photovoltaic module ratings.



Slide 9



## Using Measurement Needs to Assess the State of the USMS

- ✿ Gather Authenticated Measurement Needs
- ✿ Analyze and Aggregate
  - ✧ Sets of Measurement Needs
  - ✧ Roadmaps / Key Documents
- ✿ Apply Expertise
  - ✧ Derive Inferences / Findings
  - ✧ Authenticate Inferences / Findings

Phase I Assessment: Over 700 measurement needs were identified in 11 sector/technology areas, with input from 322 individual measurement needs and 162 technology roadmaps





## Assessment: Current Focus Areas

- ✿ Alternative Energy
  - ✧ Hydrogen / Fuel Cells
  - ✧ Biomass
  - ✧ Infrastructure / Smart Grid
  - ✧ Solar / Photovoltaic
  - ✧ Nuclear
- ✿ Nanotechnology Environmental, Health & Safety
- ✿ Core Metrology
- ✿ Sensors for Civil Infrastructure
- ✿ Carbon Mitigation Strategies
- ✿ Biosciences





## Measurement Knowledge Hub: Current Operational Features

- ✿ Measurement Needs
  - ✿ Search
  - ✿ Entry
- ✿ Blog: *A Measure Above*
- ✿ Forums
- ✿ Webinars

<http://usms.nist.gov>

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Measurement Knowledge Hub: Current Operational Features

<http://usms.nist.gov>

[ Web Slide 1 ]



## What's Next?

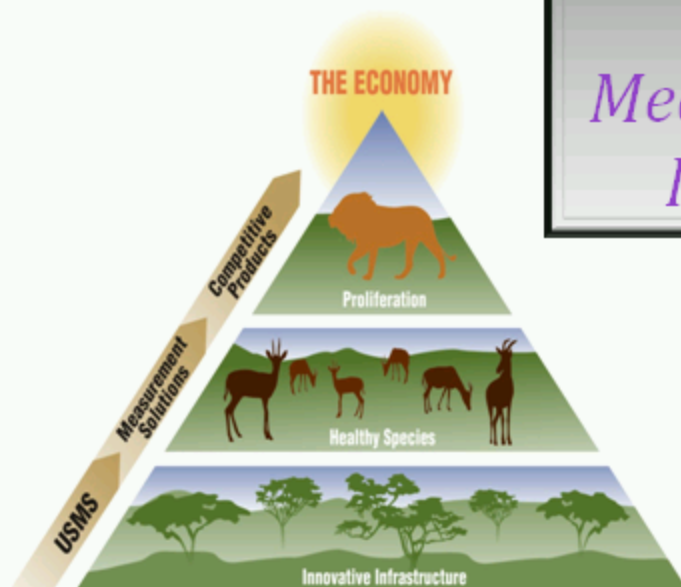
- ✿ Provide New Functionalities for the Measurement Knowledge Hub
- ✿ Release Assessment Report #2 (2009)
- ✿ Continue to Pursue Resources for Unmet Critical Measurement Needs
- ✿ Continue to Facilitate Action to Address Measurement Needs
- ✿ Continue to Promote USMS Access and Awareness



What's Next?



## The US Measurement System...



...where  
*Measurement Science* and  
*Innovation* converge

For more information:

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# Preliminary Findings: Solar Energy Measurement Needs



*Credit: Sandia National Laboratories / PIX 00036*

April 21, 2009  
Laurie Aldape  
Energetics Incorporated



Preliminary Findings: Solar Energy Measurement Needs



## Agenda

- Objectives of solar sector assessment
- Methodology
- Preliminary list of solar measurement needs (MNs)



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Agenda



## Objectives

**Is the measurement need a limiting factor in bringing the associated solar technology to market?**

- Investigate solar energy sector challenges
- Create list of preliminary MNs to start dialog
- Analyze MNs – overall trends

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Objectives





## Methodology: Overview

- Identify and review multiple publications
- Create list of solar sector subcategories
- Input preliminary MNs in database
  - MN descriptions
  - Tag MNs
- Analyze MN dataset



Methodology: Overview



## Methodology: Literature Review

- Readily available publications were reviewed. These included:
  - Roadmaps
  - Industry reports
  - Conference presentations
  - Other published material (e.g., journals, planning documents)
- Not an exhaustive review of every solar report published
- List of reviewed publications will be available on the USMS website (<http://usms.nist.gov>)
- Please suggest additional resources via USMS website forums



Methodology: Literature Review



## Methodology: Subcategories

### Subcategories created to group solar MNs

- CSP – Dish
- CSP – Linear
- CSP – Power Tower
- CSP – Thermal Storage
- CSP – General
- Low Temperature Thermal
- Passive Solar
- Solar Fuels
- General
- PV – Wafer silicon
- PV – Thin-film silicon
- PV – Concentrating
- PV – Advanced Technologies
- PV – General

Comments welcome – visit the USMS Forums ([usms.nist.gov](http://usms.nist.gov))



Methodology: Subcategories





## Methodology: Database

- Input of MNs to Access database included
  - Descriptions
  - Tags (standardized keywords)
- Database enables us to:
  - House MNs in a central location
  - Quickly analyze distribution of MNs within the solar sector and across various economic sectors
  - Easily produce reports related to MNs



Methodology: Database



## Methodology: Database

- Tags assigned to each MN allow grouping and analysis of solar sector.
- Tag categories include:
  - Subcategory
  - Stage of technology
  - Measurand (property to be measured)
  - Measurement Barrier
  - Measurement Solution
  - Solution Providers



Methodology: Database



## Preliminary MNs: Overview

- Subcategories
- Recurring themes in preliminary MNs
- Analysis of preliminary MN assessment
- Your input



Preliminary MNs: Overview



## Preliminary MNs: By Subcategory

Subcategories	MN count
CSP - Dish	NF
CSP - General	9
CSP - Linear	1
CSP - Power Tower	NF
CSP - Thermal Storage	2
PV - Advanced Technologies	16
PV - Concentrating	3
PV - General	20
PV - Thin-film silicon	7
PV - Wafer silicon	3
Solar Fuels	1
General	14
Low Temperature Thermal	NF
Passive Solar	NF

NF = not found. MNs for this subcategory may exist but were not identified in this preliminary assessment. Your input is needed! Please visit the forums and comment (<http://usms.nist.gov>).



Preliminary MNs: By Subcategory





## Preliminary MNs: PV Themes

- Recurring themes related to photovoltaic (PV) technologies:
  - Material characterization for emerging technologies
  - Understanding mechanisms in nanomaterials
  - In-line manufacturing tools
  - Accelerated life testing of products
  - Interconnection standards (will be included in future energy infrastructure assessment and webinar)



Preliminary MNs: PV Themes



## Preliminary MNs: CSP Themes

- Recurring themes related to concentrating solar power (CSP) technologies:
  - Rapid field alignment
  - Accelerated life testing of products
  - Testing new thermal storage fluids
  - Interconnection standards (will be included in future energy infrastructure assessment and webinar)



Preliminary MNs: CSP Themes



## Preliminary MNs: General Solar

- Recurring themes general to solar technologies:
  - Solar resource data (e.g., accuracy in modeled and measured data, uncertainty range)
  - Accelerated life testing of products
  - Measurement of properties and mechanisms of novel materials, especially nanomaterials

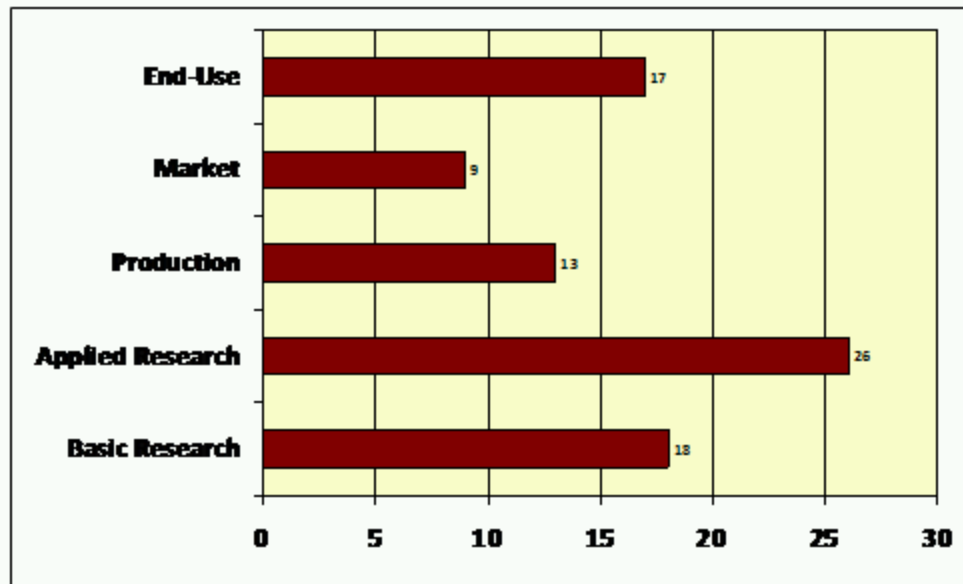


Preliminary MNs: General Solar



# Preliminary MNs

Distribution of Stage of Technology Tag Category



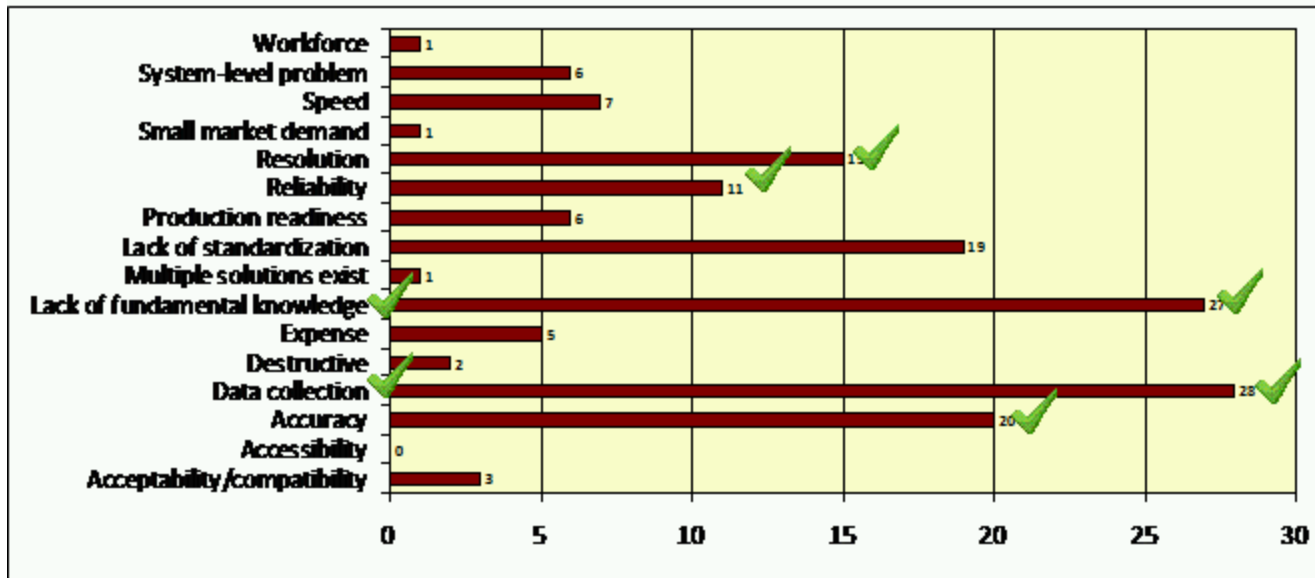
Preliminary MNs





# Preliminary MNs

## Distribution of Measurement Solution Barriers Tag Category



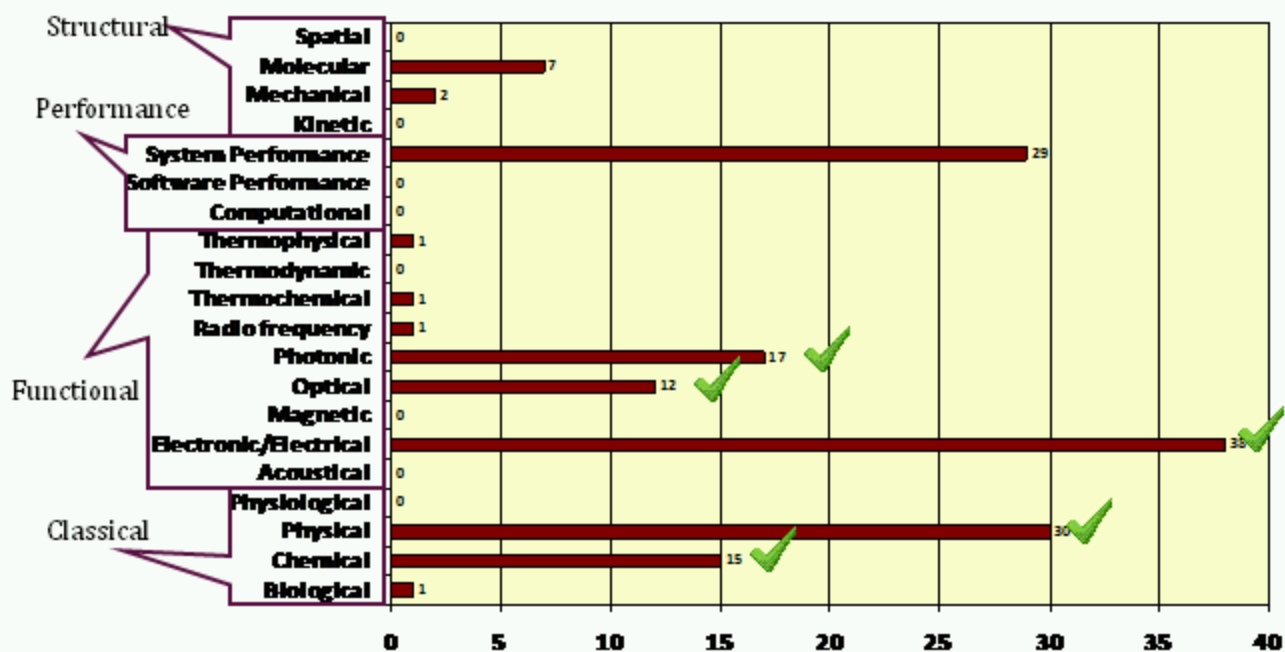
Preliminary MNs





# Preliminary MNs

## Distribution of Measurands Tag Category



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Preliminary MNs





## Correlations

Example of correlation extracted from database

Stage of Technological Innovation

	Measurement Solution Barriers															
	Acceptability/compatibility	Accessibility	Accuracy	Data collection	Destructive	Expense	Lack of fundamental knowledge	Multiple solutions exist	Lack of standardization	Production readiness	Reliability	Resolution	Small market demand	Speed	System-level problem	Workforce
Basic Research	1		4	✓ 12		2	✓ 14		3	1	2	6	1			
Applied Research	1		8	✓ 11	2	3	✓ 12		4		6	7		5	2	1
Production	1		5	3	1	1	6	1	4	4		3		2	1	
Market	1		4	2			1		3	1	4	3		1	1	
End-Use	2		3	8	1	1	1	✓ 12	1	4	2			1	5	

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Correlations



## Summary of Findings

- MNs in the solar sector are broad based
- Many of the needs for emerging technologies relate to materials characterization
- Needs for technologies on the market relate to reliability



Summary of Findings



# Preliminary MNs

- **Your input is important!**
  - Ranking/prioritizing of preliminary solar MNs
  - Joining USMS web community
  - Comment on forum posts
  - Author new MNs
  - Refine preliminary solar MNs

VISIT <http://usms.nist.gov/>



Preliminary MNs





## Next Steps

- Collect comments on preliminary solar MNs
- Authenticate preliminary solar MNs
- Grow the list of solar MNs with help from the solar energy community
- Publish report discussing this sector-specific assessment



Next Steps

**With respect to the information on Solar Energy Needs, how appropriate was the level of technical detail?**

Polls are closed.

Appropriate 

Not Enough 

Too Much 

[ Poll 3 ]

**Are you willing to co-author a Measurement Need?**

Polls are closed.

Yes   
No 

[ Poll 4 ]



## Solar Energy Community: The Path Forward

- ✿ Grow list of MNs
- ✿ Assess USMS
- ✿ Authenticate MNs and Assessment Findings
- ✿ Develop Path to Critical Measurement Solutions
- ✿ Follow-on Forums, Webinars and/or Live Workshops

<http://usms.nist.gov>



<http://usms.nist.gov>

[ Web Slide 2 ]

<http://sites.energetics.com/usmssolarsurvey09>

[ Web Slide 3 ]

**Would you be interested in a follow-on Webinar?**

Polls are closed.

Yes



No



[ Poll 5 ]

**Are you interested in participating in a Working Group on Solar Measurement Needs?**

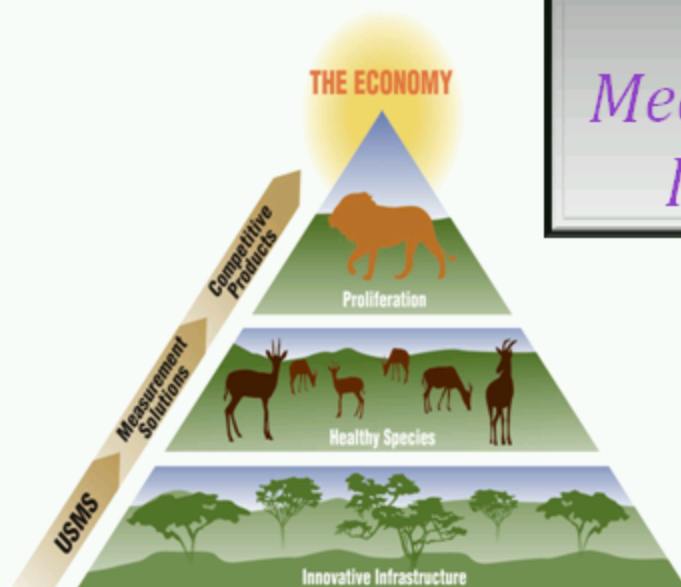
Polls are closed.

Yes   
No 

[ Poll 6 ]



## The US Measurement System...



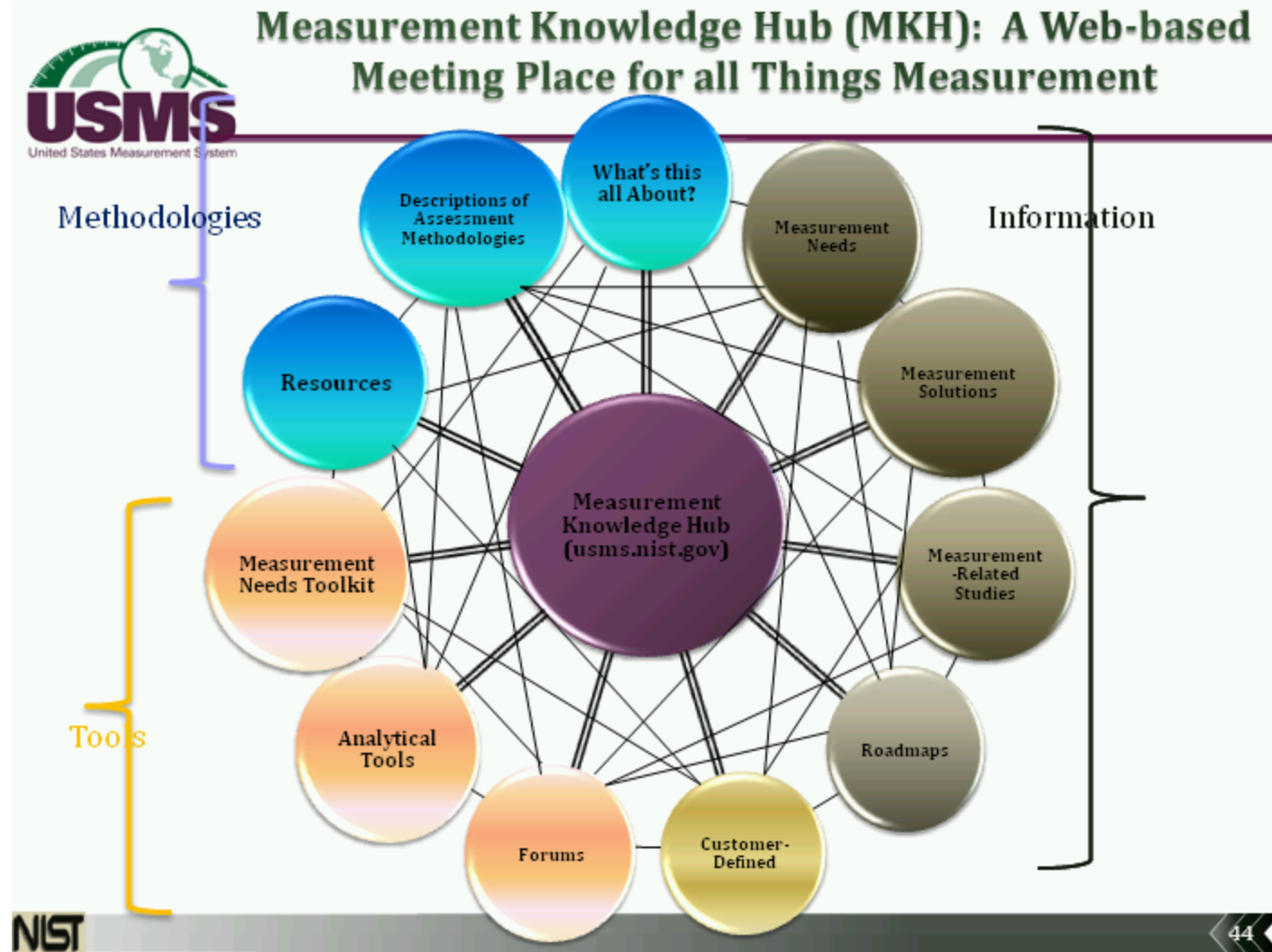
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Measurement Knowledge Hub (MKH): A Web-based Meeting Place for all Things Measurement



## Measurement Knowledge Hub: Future Operational Features

- ✿ Measurement Needs
  - ✿ Analysis
- ✿ Roadmaps Database
- ✿ Measurement Solutions
- ✿ Measurement Needs & Solutions Toolkit
- ✿ Assessment Reports



## Questions & Answers



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